SCIENCE

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*MEMORIAL ADDRESSES BEFORE THE SCIENTIFIC SOCIETIES OF WASHINGTON.**

JAMES DWIGHT DANA.

I HAVE a profound reverence and love for the memory of Dana. Nearly a quarter of a century ago, when I had returned from an exploring expedition in the plateau province, I prepared an article for the *Journal of Science* setting forth some of the characteristics of that land, especially the great blocks into which it is broken by faults and the tilting and wearing of these blocks into plateaus. In that article I characterized the faults, as such were then unknown. On sending the article Dana wrote me a long letter which led to a correspondence and an interview. The geology of arid lands is more easily read than that of humid lands, and Dana remonstrated with me about my conclusions, not deeming it possible to discover such faulting on an exploring expedition, especially as it is on a gigantic scale. Finally I visited him in New Haven, taking with me a series of sections, a body of notes and many photographs, all of which we discussed somewhat in detail. From that time Dana became my adviser and

* Given on January 14th, at a joint meeting of the Societies under the auspices of the joint commission. The address 'On Huxley and his Work' by Dr. Theo. Gill, and the address given the following evening by Dr. G. Brown Goode. 'A Memorial Appreciation of Charles Valentine Riley' will be printed in this journal.

friend, and I owe much to his wisdom and sympathetic assistance. It is thus that a feeling of gratitude impels me to render tribute to his genius.

Dana's time fell in America's first epoch of scientific research. There had been investigation in America before this time, but in the earlier part of the century there sprung up a group of scientific men born on the continent who took a prominent part in the creation of the world's stock of knowledge and who practically organized the scientific cult of America. In this brief account I cannot name all of these men, and yet I will mention ten as the leaders who, with a host of associates, inaugurated a movement which has vigorously grown to the present time and which will continue while civilization lasts. These great leaders were Henry, Logan, W. B. Rogers, Bache, H. D. Rogers, Gray, Hall, Dana, Leidy and Baird.

It must be remembered that the development of science is the work of many men, and that which one accomplishes is but a small integral part of the whole. But these men as leaders of the host established American science upon an enduring basis. The first phases of science are always ephemeral. Before scientific principles are wrought into a permanent form they must be rendered into philosophy. While many men gather the materials, the far-seeing few whose horizon is world-wide must ultimately be the master builders of philosophy.

Among the illustrious men whom I have mentioned, Dana was preëminently the philosopher. He was the man who formulated definitions, axioms and laws which are the fundamental elements of scientific philosophy. The facts must be gathered, and all honor to him who labors in the harvest field of science and adds to the inventory of significant facts; but the masters of science do more, for they organize the facts of science into a living philosophy. Science is not an architectural structure with foundation walls and dome; it is an organic living structure that develops by processes of metabolism. The facts are the constituents of the universal environment and the elements of which philosophy is constructed, and they pour into its living form to be assimilated, to play their part, and that which is perennial is the system of principles which includes all facts.

The life of James Dwight Dana exhibits a well-rounded half century of scientific investigation. For more than fifty years he was actively engaged in research, and for more than fifty years a stream of contributions to science issued from the well-spring of his genius.

For fifty years Dana was one of the editors of the *Journal of Science*, and during that time he was a constant contributor of articles on a wide range of topics, all involving original research. He was probably the best informed man in America in relation to the progress of science, and presented a resumé and criticism of research in many fields which was generous and appreciative on the one hand, far-seeing and profound on the other. Then for more than fifty years he was a professor in Yale College, conducting lectures, guiding classes and training men for scientific research, informing them with the spirit of investigation.

But his editorial and his professorial labors were the fruitage produced by the cultivation of many scientific fields. Instruction and review were always vitalized with research, and nothing came from his brain but living thought. The being of knowledge was transformed into the becoming of knowledge for himself and for the world. Dana was not only a professor and an editor, teaching and recording with wise guidance and profound appreciation, but he was also a zoölogist, a mineralogist and a geologist, and in each of these three realms of science a master. We learn that in his

youth, especially while pursuing his college course at Yale, he made a study of the plants of the region as a diligent botanist. This early study was a valuable preparation for his life's work, and its results were exhibited in the use which he made of plants in characterizing geologic periods.

In 1838 he sailed with the Wilkes expedition to explore the Pacific. This great voyage was over the mighty ocean to unknown lands of many climes, and for four years he was allured by strange sights, attracted by diverse objects of nature and thrust into the midst of a vast field of observation.

Here as a naturalist he engaged in the study of marine life, giving especial attention to the zoöphytes and crustacea, and laying the foundations of the knowledge of zoölogy which was afterward woven into the philosophy of the planet. The coral animals are animate builders of continental rocks, but he went beyond the structures which they built to study the builders themselves, their habits and the conditions under which they live. Out in those lonely seas, with savages for assistants, he studied the builders and their constructions, the animals and the atolls, the coral groves and the arboreal denizens, and returned with a vast accumulation of materials. Years were required for their elaboration. With patience this labor was performed, until at last he gave us an account of zoöphytes and also an account of the crustacea, which is in itself a monument worthy of a great man.

From his schoolboy days he pursued mineralogy as a field observer and by mathematical investigation. Early he commenced to publish on this subject, weaving the knowledge of his time into a systematic body, reënforcing his own observations by the observations of all others. Thus he was the first to give us a system of mineralogy; but his work in this field did not end at that stage. He still pursued his investigations, collecting from many fields and drafting from the collections of others in many lands, until at last he developed a new system of mineralogy, placing the science upon an enduring basis. This accomplishment alone was also worthy of a great man, and by it a new science was organized on a mathematical, chemical and physical basis.

Here we see exhibited the integrity of Dana's scientific character. In his first work on chemistry he adopted a system of nomenclature that involved a classification which then seemed to be in harmony with the practices of science, for he adopted a system analogous to that used in zoölogy which he advocated with acuteness, but further investigation revealed to him that his reasoning was wrong, that there was a more natural and scientific method, and he rent the whole fabric of his first work into shreds and rebuilt a new and better system. All honor to the man who can thus sacrifice his consistency to the truth.

While Dana was in the midst of his scientific work, Darwin announced the results of his investigations into the origin of living forms; it was a great stroke of genius. The doctrine which had been suggested and ably advocated by Lamarck was established by an inductive research in wide realms of botany and zoölogy, and new laws of evolution were discovered. But Dana had already propounded a doctrine of serial cephalization for animals, although not fully seizing the principles of evolution; still it was a long step in that direction, and he adjusted his philosophy to the new doctrine, and no great revolution was required. This was generously and thoroughly done.

We have seen Dana as a botanist, a zoölogist and a mineralogist. We are next to see him in the great work of his life, as a geologist. In 1833 he left Yale College, before graduation, to become an

instructor to midshipmen on a cruise in the Mediterranean. His first contribution to science was the result of observations made on this cruise; it is entitled 'On the Condition of Vesuvius in July, 1834.' At this early age, therefore, he began the study of volcanoes. While on the exploring expedition in the Pacific he visited the great volcanoes of the Hawaiian Islands. There is on the earth no other such region of fire as that first studied by Dana, and we may say last studied by him, for he revisited the region in his old age. Thus, on the exploring expedition he was introduced to two of the great geological agencies—vulcanism, the most conspicuous, and animal life, no less potent but less obtrusive.

On his return to the United States Dana resumed work in Yale College and continued field explorations in mineralogy and geology. The part of New England which he was led to explore is a region mainly of metamorphic rocks, and as a mineralogist he was especially equipped for such a field. It is also a region of glaciation, and he threw his energies into these two fields, which at that time were obscure. On the one hand he found glaciation interpreted simply as iceberg transportation, and on the other as a universal or almost universal ice period. These theories never led him astray, but with careful and persistent labor he unraveled the problem, and, perhaps more than any other man of his age, succeeded in putting glacial geology upon a sound basis. Equipped as a botanist, deeply versed in zoölogy and a great contributor to knowledge in that department, the leading mineralogist of the world, and no inferior chemist, the geology of the country became his theme, and with it the geology of the planet. At last he formulated a general system of geology, which has become the standard in America. His researches in the field were extensive, but they were reënforced by all the geological workers on the continent and the whole geological literature of Europe. So Dana's geology is not only a text-book of geology, but it is the hand-book for all National, State and local geologists, and all students in the field. It is the universal book of reference in that department of science. Other text-books have been developed, but no other hand-book for America. It is a vast repository of facts, but all arranged in such a manner as to constitute a system of geologic philosophy. It is on every worker's table and is carried in the kit of every field observer. It has thus become the standard to which all scientific research is referred, and on which geologic reports are modeled. Of the ten great men who organized science, five were geologists—Logan, the Rogers brothers, Dana and Hall, who yet remains with us. May he be long in the land!

Dana as a zoölogist was great, Dana as a mineralogist was greater, but Dana as a geologist was greatest, and Dana in all three was a philosopher, hence Dana's great work is enduring.

It thus came about that Dana wrought his work into a systematic body of science. The ruins of ancient towns and cities are widely scattered over all the earth, and the arts there entombed are disinterred as evidences of former culture, but we do not study ancient arts for the sake of imitating them; ancient art never becomes the model for modern art. The tribes and nations of antiquity are themes of investigation, but ancient institutions never become the models for modern institutions. Ancient languages are the themes of study, but never more will ancient languages become the models for modern languages. So ancient opinions are of profound interest, but ancient opinions will never again become the models for modern opinions. We study the past for the history of the past, not as a model to be imitated, but as exhibiting

the laws of culture, and by these laws learn to construct a better future. Thus we study the philosophy of the past, not that we may adopt that philosophy, but that we learn the laws of progress and avoid the errors of the past and construct a wiser future.

In the history of philosophy two lessons are plainly taught. The first is that no man can evolve an enduring philosophy from his own thought, but that philosophy must be evolved from facts, for the wrecks of such philosophies are scattered over the pages of thought from the time of Plato to the time of Hegel. The second great lesson is this, that the construction of an enduring philosophy is not the work of one mind, but of a multitude of men who gather their materials by scientific research. Since the days of Aristotle the wrecks of such attempts have strewn the highway of history. Even Descartes failed to do more than to make a contribution, while Newton and Darwin gave us but materials for philosophy, not philosophy itself. A host of men have engaged in this work collecting and organizing materials, and another host yet to live must carry on the work ere a scientific philosophy is developed, while the structures which have hitherto been developed mark but the stages of growth and those philosophies which have been wrought of pure thought; thought not informed by fact, are great lighthouses of warning to guide us from the rocks. It is thus as a philosopher of the scientific school that Dana's name will be remembered and Dana's contributions forever remain.

In a quiet street of the good old town of New Haven, Dana labored far from the turbulent crowd, absorbed in facts of observation and acquisition, loving and loved as only the quiet student can love and be loved. No pageantry marked his life, no glittering honors shed their luster over his career; he built only as the philosopher builds and he lived only as the philosopher lives.

The thoughts of early man are now unknown;
In all the tomes of world no page is his.
The grand phenomena of arching heaven,
The wondrous scenes of widespread earth and sea,
The pleasure sweet and bitter pain of life,
As these are known to-day so were they then,
But all in psychic terms of simple men.

And yet his thoughts live on to later time.
As mind has grown the thoughts have been enlarged,
Revolving oft in human soul through life,
In grand endeavor yet to reach the truth,
Repeated o'er by streams of countless men,
And changing e'er with mind's expanding view,
Till errors old have grown to science new.

With knowledge gained man never is content:
Nor wold, nor mount, nor gorge, nor icy field,
Nor depths of sea, nor heights of starry sky,
Can daunt his courage in this high emprise,
Or sate the vision of his longing eyes.

J. W. POWELL.

PASTEUR.

LADIES AND GENTLEMEN: I am to speak to you of the life and achievements of one who has won imperishable renown by his valuable contributions to human knowledge, and who has recently been buried in the city in which his scientific labors have been prosecuted, with all the honors which it was possible for a grateful people to confer. It is certainly a happy augury for the future when the man of science, whose achievements have been the result of painstaking and laborious work in the laboratory, receives the grateful plaudits of his fellowmen during his life time and the honors which were formerly only paid to civil potentates or military heroes when his body is committed to the tomb. It has been the fortune of few men to contribute so largely to the sum of useful knowledge, and fewer still have lived to receive such ample recognition of the value of their scientific work.

Pasteur's success has been due to a combination of personal qualities which especially fitted him for the pioneer work which